California Department of Forestry & Fire Protection (CAL FIRE) Reforestation Services Program 2023 Assessment of Needs for the State Seed Bank

EXECUTIVE SUMMARY

Scope and objective: Establish an analytical process for targeted conifer seed collection throughout California.

Methods Used: Geographic Information Systems (GIS) data layers were used to provide baseline forest land mass areas, seed zones, elevation bands, and wildfire perimeters. The dataset generated was then exported for further analytics to target desired species, incorporate CAL FIRE's Seed Bank inventory, nursery requirements, and CAL FIRE Units to obtain the target number of conifer cone bushels to reforest 25 percent of forest land area in California.

Findings and recommendations: A grand total of 76,304 bushels of conifer cones would need to be collected throughout the various seed zones, elevations bands, and species to address 2023 needs. While this Assessment of Needs (AON) is extensive, the recommendation is to use this document as a guide with the datasets subject to amendments as variables change.

ABSTRACT

The purpose of the seed needs assessment is to provide a structured framework for directing the seed collection resources of the California Department of Forestry & Fire Protection's (CAL FIRE's) Reforestation Services Program (RSP), targeting and prioritizing efforts across all 85 seed zones and all 500-foot elevation bands for all native conifer tree species within all forested

landscapes of State Responsibility Area (SRA) within the State of California. The information contained within this document should be seen as first, a tool for RSP staff, second, as a guide for internal and external collaborators, and third, as a resource for general consumption.

CAL FIRE has a need for a systematic way to estimate the number of bushels needed for collection that will be needed to grow sufficient seedlings for reforestation on state and private forest lands. In this analysis, spatial data layers were used to identify areas of productive conifer species and where they intersected with elevation, seed zones, and, as a proxy for disturbance, wildfire history. That information was then used to calculate carrying capacity and deviation below those productive thresholds (or seed lots). When combined with the results of the RSP's existing seed inventory, a concerted approach to cone surveying and collection can be made to replenish seed lots of greatest need. The results of this inaugural exercise for 2023 are attached in the Excel table, titled "2023 Seed Bank AON", to be shared with internal and external cooperators with the expectation that datasets are revisited, and a corresponding report and table produced annually.

BACKGROUND

Healthy forests provide a multitude of benefits. Wood products, wildlife habitat, clean water and air, recreation, education, and steady employment are but a handful of the immense values they support. Recognizing the vast environmental, economic, and social benefits of this natural resource, it is incumbent on resource managers to improve forest conditions and lessen threats in the face of climate change and persistent drought, as well as forest disturbances including catastrophic wildfire, insect and diseases, and poor forest management and land conversion.

From at present, an estimated 165 million trees died in California forests, primarily in the Sierra Nevada Mountain range, due to severe drought and the resulting insect and disease (USFS, 2017) (Table 1). Wildfires also dominated the landscape during the drought and almost

doubled in acres consumed, compared to historic totals (Table 1). In the four years that followed (2018-2021), an additional 8,175,583 acres were consumed by wildfire throughout the state. Due to the devasting tree mortality (including that of parent seed trees), increased wildfire, as well as other biotic and abiotic factors, there grew an increasing need for post-disturbance reforestation and thus a surging demand for seeds and seedlings.

Year	Tree Mortality (in Millions)	Acres Burned by Wildfire
2010	3.1	101,474
2011	1.6	202,427
2012	1.8	847,715
2013	1.3	569,437
2014	3.2	570,895
2015	29	789,215
2016	62	545,977
2017	27	1,424,599

Table 1: Disturbance During the Drought (USFS Region 5, CAL FIRE)

To help meet the mounting need for reforestation services on SRA lands, CAL FIRE operates a single Reforestation Center for the entire state, located in Davis, California. The center encompasses the only remaining State-run conifer seed bank and nursery. Established in 1921, the Lewis A. Moran Reforestation Center (LAMRC) has provided reforestation resources to public and private non-industrial landowners throughout the state of California in the form of seeds and seedlings for over 100 years. Unfortunately, due to budget restrictions, the nursery portion of LAMRC was shut down in 2006. The seed bank remained functional and continued to collect, process, and store seeds with drastically reduced staffing. In 2017, a Budget Change Proposal adopted by California State Legislature, allowed for additional staffing for the RSP as well as related infrastructure and facility upgrades at LAMRC to expand seed storage capacity along with the necessary nursery equipment to eventually increase production of up to 1 million seedlings annually for forestland owners. While those improvements have yet to fully

materialize, and despite fluctuations in yearly funding, the RSP has maintained CAL FIRE's ongoing mission to serve and safeguard the people and protect the property and resources of California.

The State Seed Bank staffing remains minimal, employing 3 full time employees and 2-3 seasonal hires. These employees not only manage seed requests made by forestland owners but engage in the day-to-day processing of cones and seeds, as well as the coordination of surveys and collections of cones from field locations at optimal times of year. During 2021, this staff engaged in the processing of over 2,000 bushels of various conifer seeds and the sale and distribution of 170lbs of seed comprised of 14 native tree species totaling 38 unique orders within 17 different seed zones. While very dedicated and productive, the Seed Bank suffers not only from limited staffing, but antiquated processing and accounting systems, as well as restricted storage capacity.

Cone surveys, which serve as the first step in reforestation pipeline, are inconsistently done, historically, by regional unit foresters with many conflicting duties, and the results of which are usually submitted to the RSP on paper sheets with limited accuracy or utility. Personnel, experience, and leveraged technology are not only lacking for the surveying of ripening cones but in their collection as well. Current practices see but a handful of experienced surveyors and collectors utilizing binoculars and traditional climbing practices to gather intelligence and materials from forest stands which are not always themselves accessible or practical for harvesting. Aside from minor investments in cooperative seed orchards out of state, the RSP

lacks a steady supply of farmed or genetically bred seed stock, and thus, relies on the intricacies of wild seed collections on lands not owned by the State which require access agreements and other negotiations. In factoring in the related struggle of demand for reforestation materials far outweighing supply, and the compounding obstacles that add to site preparation as time before replanting lengthens, the entire industry is facing increasing adversity.

All these processes are in some form of being updated and modernized as staffing/funding increase and attention is given to the importance of growing the reforestation supply pipeline, however this does illustrate the challenges we currently face.

With the many challenges that hamper adequate reforestation of degraded forestlands a methodical approach needs to be employed routinely to evaluate a prioritized and enhanced response to the needs of these crucial landscapes in California.

Further enabled by the goals of the 2021 California Wildfire and Forest Resilience Action Plan, CAL FIRE is working to meet the following key actions relative to its RSP, as follows:

> 1.15 Provide Seedlings for Restoration: CAL FIRE will expand its nursery and seed bank to deliver seeds and seedlings to small landowners whose properties are affected by wildfire or diseases. Experts will focus on using native seed selections that are best suited to current and future landscapes.

1.34 Develop Coordinated State Restoration Strategy: California Natural Resource Agency (CNRA) will partner with the California Office of Emergency Services (Cal OES), The Office of Planning and Research (OPR), and other federal, state, and local agencies to develop a coordinated strategy to prioritize and restore non-federal burned areas and communities as part of the state's overall long-term recovery and resilience strategies.

METHODOLOGY

RSP staff realizes that a rational approach to estimate the number of seed to grow sufficient numbers of seedlings to restore California's state and private forests is needed. An Assessment of Needs (AON) was developed in conjunction with this report to determine how many bushels of seed need to be collected to reforest 25% of productive conifer forests on non-Federal lands at any given time throughout the state of California. Twenty five percent was determined to be an obtainable goal for the affected lands realizing the inventory of seeds, capacity of nurseries and site considerations and practicality of regeneration practices in those areas. This AON for the State Seed Bank was developed using a spatial approach identifying conifer forest on state

and private lands. These areas were then identified by species, 500-foot elevation bands, seed zone, and comparing that against locations of wildfires occurring from 2012 to 2023 and matched against the State Seed Bank inventory. The AON allows a methodical approach for allocating State-held resources to areas of highest priority for reforestation as well as defining programmatic areas necessary for increased success. The assessment not only allows us to best allocate our resources in the form of surveying and collecting cones but can give us internal directives as to how to strategize other initiatives like investment in related seed tree orchards, prioritizing limited processing and freezer space, collaborating with industry partners to formulate response plans, directing funding for local projects, and other endeavors.

Due to the novelty of the approach, and the fact this this is the first attempt at it, this iteration should be considered a beta version, with more nuanced versions yet to come. In addition to wildfires, we will seek to use more refined and descriptive disturbance variables such as areas of tree mortality. It may be deemed that a regional approach, based on more delineated topographic and climatic descriptions, other than seed zone, could be further assistive. Support of advanced tools and protocols should also be considered to make the process more streamlined and efficient. CAL FIRE's Fire and Resource Assessment Program (FRAP), along with the Reforestation Services Program staff used spatial data and Geographic Information System (GIS) overlay analysis using Environmental Systems Research Institute (ESRI) software. The data comes predominantly from CAL FIRE, apart from a digital elevation model (DEM) from the United States Geological Survey (USGS). The results of the analysis are both a visual representation of the data as well as a functional tool that allows the user to estimate the bushels needed to successfully regenerate specific species of conifer forests.

The following is a list of the steps followed to perform the analysis.

A. <u>Establish the spatial extent of the analysis, focused on productive conifer forest.</u>

The LA Moran seed bank collects seed primarily for regenerating conifer forests on non-industrial private forestlands as well as State-owned public lands. These lands are the focus of the analysis.

To identify conifer forests, CAL FIRE's FVEG15_1 (forest vegetation) GIS layer was used. FVEG15_1 uses the California Wildlife Habitat Relationship Classification System (CWHR) to identify vegetation communities. While initially intended as a tool for wildlife conservation, CHWR also provides an invaluable database of vegetation.

We filtered FVEG15_1 to include only conifer vegetation types (Life_Form = Conifer). CWHR also provides a finer-grain description of the species type as a subset of conifer, such as Sugar Pine, Douglas fir, or Incense Cedar (Figure 1). Some of the species' descriptions are broad categories such as Mixed Sierra Conifer. For these associations, RSP staff researched what a typical percentage of species common to the association was and broke it out accordingly.

FVEG reports what is on the ground at the time the data layer was created. CAL FIRE has a spatial layer that depicts productive timberlands, whether the areas are currently forested or not (CA_Timberland13_1). For example, an area that has been recently harvested will be reported as primarily shrub in FVEG but will be reported as productive timberland in Timberlands (Figure 2). CAL FIRE's Timberlands layer is originally from the Region 5 United States Forest Service (USFS). This layer is also primarily derived from CalVeg, the USFS's fine-scale vegetation mapping product. Region 5 has added an attribute to assess the type of timberland. FVEG was used as the starting point for identifying conifer forests and productive timberlands were used to complete a depiction of conifer forests that may not be currently forested.

The analysis focused on state and private lands and so needed to exclude federal lands. We used the CAL FIRE layer SRA (State Responsibility Area), which identifies lands that fall within the State Department's jurisdiction for fire protection, Federal Responsibility Area for fire protection (FRA), and Local Responsibility Area for fire protection (LRA). We filtered for FRA and deleted all conifer and timberlands that fell under it. Combining both layers (conifer and

productive timberlands) and excluding federal lands, we determined the spatial extent of our analysis, referred to as the "footprint" of the analysis (Figure 3).

B. Determine Species Distribution

The footprint defines the spatial extent of the analysis (conifer forest on State Responsibility Areas). It also provides species distribution through the inclusion of the WHR classes from FVEG which describes a detailed list of species. Some classes are composites, such as "Sierran Mixed Conifer". Nursery staff used reference guides to estimate percentages for species found within those composite types.

C. Climate, elevation, and disturbance

The collection of seed for successful regeneration should account for environmental variables as species differ in growth and success depending on climate, soils, and elevation. We used seed zones to account for climactic and soil variation throughout the state. Seed zones are defined by major areas in California having similar climatic, topographic, and soil conditions. The original mapped seed zones were first proposed in 1946 with the most recent version having been revised in 1966 and published as part of a joint report between the USDA Forest Service and CAL FIRE in 1970. Denoted by a three-digit identifier and broken out into 85 distinct zones within 32 subregions contained within 6 overarching regions, the map attempts to base the location of native tree plantings within close proximity and elevation to the collected seed source from which those trees were propagated.

The regions, known as Physiographic and Climatic Regions are depicted by the first digit in the three-digit designation for each seed zone. Divisions of the regions, called subregions, were delineated based on the next lower level of environmental changes known to affect growth and adaptability of plants. These are designated by the second digit in the three-digit seed zone number. Divisions of the subregions, called subzones, are indicated by the third digit in the three-digit seed zone number. Individual subzones within subregions were defined based on

the overall framework of approximately 50 miles in latitude and further refinement in uniformity of environment within subregion. Subzone boundaries were made to follow natural or physical features (FRAP, 2003) (Figure 4).
We used elevation to further incorporate climatic and soil variation. A 30-meter resolution digital elevation model (DEM) from the USGS depicting elevation was grouped into 500-foot bands (Figure 5).

To include a disturbance variable, we used wildfire perimeters from the past 10 years for fires 100 acres or greater in size. These data came from FRAP's fire perimeter dataset that include wildfires managed by state, local, or federal agencies for the past 100 years. FRAP's dataset is updated to the past wildfire year. To include fires that were more recent, we used the National Interagency Fire Center wildfire dataset for the year 2023 (https://data-nifc.opendata.arcgis.com) (Figure 6).

The wildfire perimeters indicate areas of potential disturbance where reforestation may be necessary. However, wildfires vary in burn severity, and thus, vary in disturbance and need for reforestation across the spatial extent of the fire. One potential improvement of the analysis would be to incorporate burn severity across private and state lands.

D. Generating footprint for analysis

The analysis footprint (conifer and timberlands with federal lands excluded) was overlayed with seed zones, elevation bands, and species composition data layers. The result of this overlay was information about the acreage of species that occurred in each unique combination of seed zone, elevation band, and wildfire perimeter. As new fires emerge, additional site-specific analyses of seed needs will be generated to influence collection needs each year. CAL FIRE RSP staff used this to generate a tool that can help estimate seed need for each species at a particular elevation band and seed zone, while also having the ability to target disturbed (burned) areas.

E. Generate a relative percent of each target species within each elevation band from footprint

The table generated from the spatial layer overlay in Figure 7 obtained the target acres, or the acres needed to be converted to target numbers of bushels needed to be collected. Tabular data (Appendix A) from the layer generated above encompassed 54 classifications sourced from CWHR and described as unique name of each Wildlife Habitat Relationship class (WHRNAME) for each seed zone and 500' elevation band. These classifications were filtered to applicable conifer species:

1. Douglas Fir
2. Eastside Pine
3. Jeffrey Pine
4. Klamath Mixed Conifer
5. Lodgepole Pine
6. Montane Hardwood-Conifer
7. Ponderosa Pine
8. Red Fir
9. Redwood
10. Sierran Mixed Conifer
11. Subalpine Conifer
12. White Fir

While not the only species present in the State Seed Bank, the above-mentioned species are the primary species or forest types that are requested and focused on due to demand and storability. As such, hardwoods, like oaks, maples, and walnuts, as well as native conifer species of less commercial value, such as Torrey pine and Monterey pine, are not included. This is not to suggest that the Reforestation Services Program will not collect these species, but for the purposes of prioritizing the most requested tree species to support reforestation, the above species were the initial focus. The RSP will always serve as a genetic library for native tree species in California and will employ more localized prioritization for special status species when available for collection. As the RSP matures and expands, we will begin to include

hardwoods and other native shrubs. CWHR classifications: Eastside Pine, Klamath Mixed Conifer, Montane Hardwood-Conifer, Sierran Mixed Conifer, and Subalpine Conifer are comprised of a species mix. These were further subdivided to the column WHRNAME_breakdown based on the CWHR description of the vegetation composition for each seed zone, elevation band and acres. A target of 25% reforestation acres for all species was calculated with the assumption that species are equally distributed.

F. <u>Generate trees per acre and total pounds per target species for each 500’ elevation band in each seed zone.</u>

An average stocking requirement of 200 trees per acre (TPA) was applied to targeted reforestation acres for all species found above. This number was derived as an acceptable average carrying capacity for forestlands relative to CA Forest Practice Rule (FPR) requirements that can range between 100 and 450 TPA depending on location and forest management prescriptions. This stocking requirement was applied and generated the number of total trees needed to reforest target acres in each seed zone and elevation within a 500’ elevation band (Appendix A) with the assumption of each acre needing maximum stocking in the worst-case hypothetical scenario.

Conifer seed collections are classified as number of bushels needed in terms of harvesting based on species. One bushel consists of 9.3 dry gallons per volume of cones. A conversion is needed to get from acres to number of bushels (Appendix A). The process comprises determining, on a per species basis; the average seed per pound, average seedling produced per pound, number of pounds needed to collect, and finally number of bushels needed. Datasets for those processes were obtained as follows:

Average seed per pound

LAMRC inventory data consisting of 946 entries were used to obtain data averages per species.

Average seedlings produced per pound.

= (average seed per pound/average seed per pot) x percent survival rate in nursery x average probability of a tree in nursery.

Historical LAMRC nursery datasets were used for:

i. number of seeds per pot—is determined based on the germination calculations.
ii. percent survival in nursery—seed that germinated and grew to a two-year seedling.
iii. average probability of tree in nursery—seedlings that were thinned and were able to be transplanted.

Number of pounds needed to collect.

= (number of trees in reforestation acres/average seedlings per pound)

Number of bushels needed.

= (number of pounds needed to collect/average pound of clean seed per bushel).

Clean seed is defined as seed that has been processed to have >95% purity, <9% moisture content, and is ready for long-term storage. Bushels were rounded to whole numbers.

Average pound of clean seed per bushel was obtained via historical records shown in Table 1. For species not represented in the table, a conversion of one bushel of seed equaling one pound of seed was assumed.

Table 2. LAMRC records of average number of cones and clean seed obtained per species.

Species	Avg. No. Cones/Bu	Avg. Lb. Clean Seed /Bushel
Jeffrey Pine	35-50	1.2
Ponderosa Pine	90-100	1
Sugar Pine	12-18	1.4
Coulter Pine	10-12	0.9
Incense Cedar	1000s	0.7
White Fir	170-200	1.1
Red Fir	50-65	0.9
Douglas Fir	900-1000	0.5
Douglas-fir Sierra	700-900	0.75
Big-Cone Douglas Fir	300-400	0.75
Coast Redwood	1000s	0.75
Sierra Redwood	1000s	0.75

Current LAMRC seed bank inventories (comprised of wild and orchard seeds) are measured in pounds which were also converted to bushels needed based on process # 4 detailed above. Inventory datasets were matched to the spatial dataset in Appendix A based on species, elevation, and seed zone. Deficits are shown as positive numbers and excess is shown as negative numbers in column titled “actual bushels needed” for each species in each elevation within a 500’ elevation band (Appendix B).

G. Comparison of fire data to affected areas per seed zone.

1. Generate map of fire scar areas.

Fire data layer “Fire2012 to2023” from the Fire and Resource Assessment Program (FRAP) was overlayed on the base layer with purple indicating burned areas.

2. *Compare that to seed zone area and generate area burned.*

While all areas are of concern, to establish priority, areas were filtered to fire perimeters >100 acres that were located on private, non-federal land between 2012-2023. Acreage of fire is broken down based on seed zone, and extent of fires can cover multiple seed zones which is represented in acreage amount (Appendix C).

G. Final bushel needs

The 2023 Seed Bank AON is an extensive list representing a spatial analysis baseline of the number of bushels required to reforest 25% of private, non-industrial land to account for typical reforestation along with burned areas where fires burned >100 acres within each seed zone and 500’ elevation band.

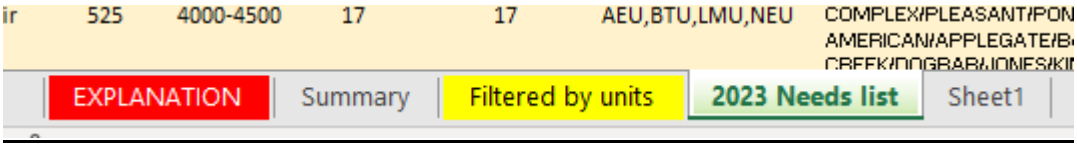
To establish priority:

1. Areas are sorted by acres burned—highest to lowest.
2. Colors were assigned as a visual indicator of priority. Where number of bushels needed was higher than 100, red was assigned. Bushels needed between 11 and 100 a medium priority or color yellow was assigned. Lowest priority was given for bushels needs less than 10.
3. Each species within each unit/seed zone is grouped from highest to lowest elevation.

Key		
Color	**Priority**	**No. of bushels**
	HIGHEST	>100
	MEDIUM	11>100
	LOW	<10

Number of bushels are matched to LAMRC inventory. Positive numbers indicate deficits and negative numbers indicate surplus. Summary tab and Grand Totals are summations of **all positive** numbers.

Data can be sorted and narrowed down in “2023 Needs list” (green tab).



CONCLUSION

As of May 2023, a total of 76,304 bushels of conifer seed needs to be collected throughout the entire state of California to accomplish the 25% reforestation goal statewide on the lands included. The intent of this approach is to incorporate quantitative data to provide a guide for areas to focus resources and collection efforts on. Logic and rationale still need to be implemented with the AON acting synergistically with recommendations from a Registered Professional Forester or other qualified land managers in the field.

Internally, the AON is being used to assist CAL FIRE Unit Foresters and their staff by providing a list of species, per seed zone, and elevation band that can be tailored to match cone survey routes when possible. This can be seen in the “Filtered by units” tab in yellow above. Externally, CAL FIRE is using the AON to assist with discussions surrounding seed acquisition and collaborations with private industrial timberland owners, other government organizations, non-profits, and research institutions.

CAL FIRE's Reforestation Services Program looks forward to making annual updates to this document, related tools and guidance in hopes that refined methodologies and enhanced data will better serve the purposes of this assessment. Please refer to the contributor's section below with any questions or concerns.

GLOSSARY OF TERMS

Assessment of Needs (AON) - Also referred to as the "Seed Needs Assessment", i.e. this document. Accompanied by quantified, tabular, localized data, this analysis is designed to be conducted yearly by CAL FIRE staff and shared internally as well as with cooperators to better assess where source tree materials are needed at defined levels.

Budget Change Proposal (BCP) - A formal document required when an office needs additional resources or reduction of resources to change the level of funding for activities that need to be authorized by the State Legislature.

Bushel - Measurement of dry volume of tree cones, represented as 9.3 gallons.

California Department of Forestry and Fire Protection (CAL FIRE) - California Natural Resources Agency's fire department whose mission is to serve and safeguard the people and protect the property and resources of California. It does this by supporting staff engaged in engineering; research, development, and adoption of regulations; fire and life safety programs; fire prevention, law enforcement, and public information and education; resource protection; and emergency response.

California Wildlife Habitat Relationships (CWHR) - Information system maintained by the California Department of Fish & Wildlife containing life history, geographic range, and management information for 712 species of amphibians, reptiles, birds, and mammals, and

other organisms that occur within the state. It also contains detailed information on 59 habitat types, their spatial distribution, and their vegetation types.

California Wildfire and Forest Resilience Action Plan - A strategy to restore the health and resilience of California forests, grasslands, and natural places. In addition, improve fire safety of communities and sustain the economic viability of rural forested areas.

Digital Elevation Model (DEM) - A computer graphic based on elevation data. It is comprised of cells of a certain length and width as well as their elevation above zero. They are used to represent topography and elevation.

Federal Responsibility Area (FRA) - Areas where the federal government has jurisdiction to first respond to emergencies to include wildfires. These areas are marked primarily by federal ownership, such as National Forests, National Parks, lands owned by the Bureau of Land Management, the United States Military and others.

Fire and Resource Assessment Program (FRAP) - A CAL FIRE program whose primary function is to analyze spatial data, model environmental variables, and create environmental spatial data layers to inform land management. FRAP assesses the amount and extent of California's forests and rangelands, analyzes their conditions, and identifies alternative management and policy guidelines.

Forest Practice Rules (FPRs), aka Forest Practice Act – Laws enacted in 1973 and enforced by CAL FIRE that regulate logging on privately-owned lands in California to ensure it is done in a manner that will preserve and protect fish, wildlife, forests, and streams.

FVEG - A GIS forest vegetation layer created by FRAP combining the most current (2015) and highest spatially accurate vegetation samples into one layer. It uses the CWHR to represent vegetation classification.

Lewis A. Moran Reforestation Center (LAMRC) - See ***Reforestation Services Program*** and ***State Nursery***.

Local Responsibility Area (LRA) - An incorporated area where the local government is responsible for providing emergency services including fire protection. Emergency response in these areas is typically provided by city fire departments, fire protection districts, counties, and by CAL FIRE under contract.

Reforestation - Replanting trees (aka artificial regeneration) or supporting the regrowth of trees from seed and stump sprouting (aka as natural regeneration), in previously forested areas that have been affected by both natural and/or unnatural disturbances.

Reforestation Services Program (RSP) - Based out of the LAMRC in Davis, CA, the RSP is a CAL FIRE Resource Management Program whose mission is to provide California landowners and managers with resources needed to restore disturbed lands to maximize the values of highly productive forests.

Seed lot - A uniform quantity of seed within a permitted tolerance for percentage of pure seed and other crop and inert matter.

Seed Zones - An inventory system that classifies seeds for collection and planting by physiographic zones. Major areas in California having similar climatic, topographic, and soil conditions are given the name "Physiographic and Climatic Regions." These are areas where plant materials can be moved or transferred with minimal risk of being poorly adapted to new location.

State Nursery - CAL FIRE-owned and operated facility that grows tree species for forest restoration purposes for private and public landowners utilizing native seed stored at the State Seed Bank. While there were previously multiple sites operating as such, the only facility in operation currently is the Lewis A. Moran Reforestation Center (LAMRC) in Davis capable of growing approximately 250,000 1-year seedlings.

State Responsibility Area (SRA) - Areas where the State of California has the primary responsibility for providing emergency services including fire protection. The emergency service is typically provided by CAL FIRE.

State Seed Bank - CAL FIRE-owned and operated facility in Davis, CA that processes and stores native tree seed for on or off-site growing at nurseries for forest restoration purposes for private and public landowners. A zero-degree freezer currently is able to preserve over 40,000 pounds of various seed at this site.

Stocking - A measure of the degree to which space is occupied by well-distributed countable trees on forested land per the California Forest Practice Rules.

Timberland - Land, other than land owned by the federal government and land designated by the board as experimental forest land, which is available for, and capable of, growing a crop of trees of a commercial species used to produce lumber and other forest products, including Christmas trees.

Trees Per Acre (TPA) - The average number of trees, of a given size, present on any one acre of a forested tract.

Unit - Also known as a CAL FIRE Administrative Unit, these represent the 21 geographical response areas within California that provide resource management and fire protection services.

USDA Forest Service (USFS) - Agency of the U.S Department of Agriculture that administers the nation's 154 national forests and 20 national grasslands.

United States Geological Survey (USGS) - Agency of the United States Department of Interior that studies the landscape of the United States, its natural resources and the natural hazards that threaten it. It is the nation's largest water, earth, and biological science and civilian mapping agency.

CONTRIBUTORS

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RESOURCES

California Department of Fish & Wildlife (CDFW) California Wildlife Habitat Relationships - https://wildlife.ca.gov/Data/CWHR

California Department of Forestry & Fire Protection's (CAL FIRE's) Forest & Resources Assessment Program (FRAP) (including maps) - https://frap.fire.ca.gov/

CAL FIRE's Reforestation Services Program (Reforestation Center) - https://www.fire.ca.gov/programs/resource-management/resource-protection-improvement/wildfire-resilience/reforestation-center/

California Forest Practice Rules - . https://bof.fire.ca.gov/regulations/bills-statutes-rules-and-annual-california-forest-practice-rules/

California Tree Seed Zones (publication, 1970) - https://www.fs.usda.gov/research/treesearch/41438

California's Wildfire & Forest Resilience Action Plan (2021) - https://wildfiretaskforce.org/the-plan/

United States Forest Service (USFS) CalVeg - https://www.fs.usda.gov/detail/r5/landmanagement/resourcemanagement/?cid=stelprdb5347192

USFS Reforestation Toolbox - https://www.fs.usda.gov/t-d/seedlings/conecoll/colmeth.htm

Photo Credit:

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Christine McMorrow – CAL FIRE

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APPENDICES

Figure 1

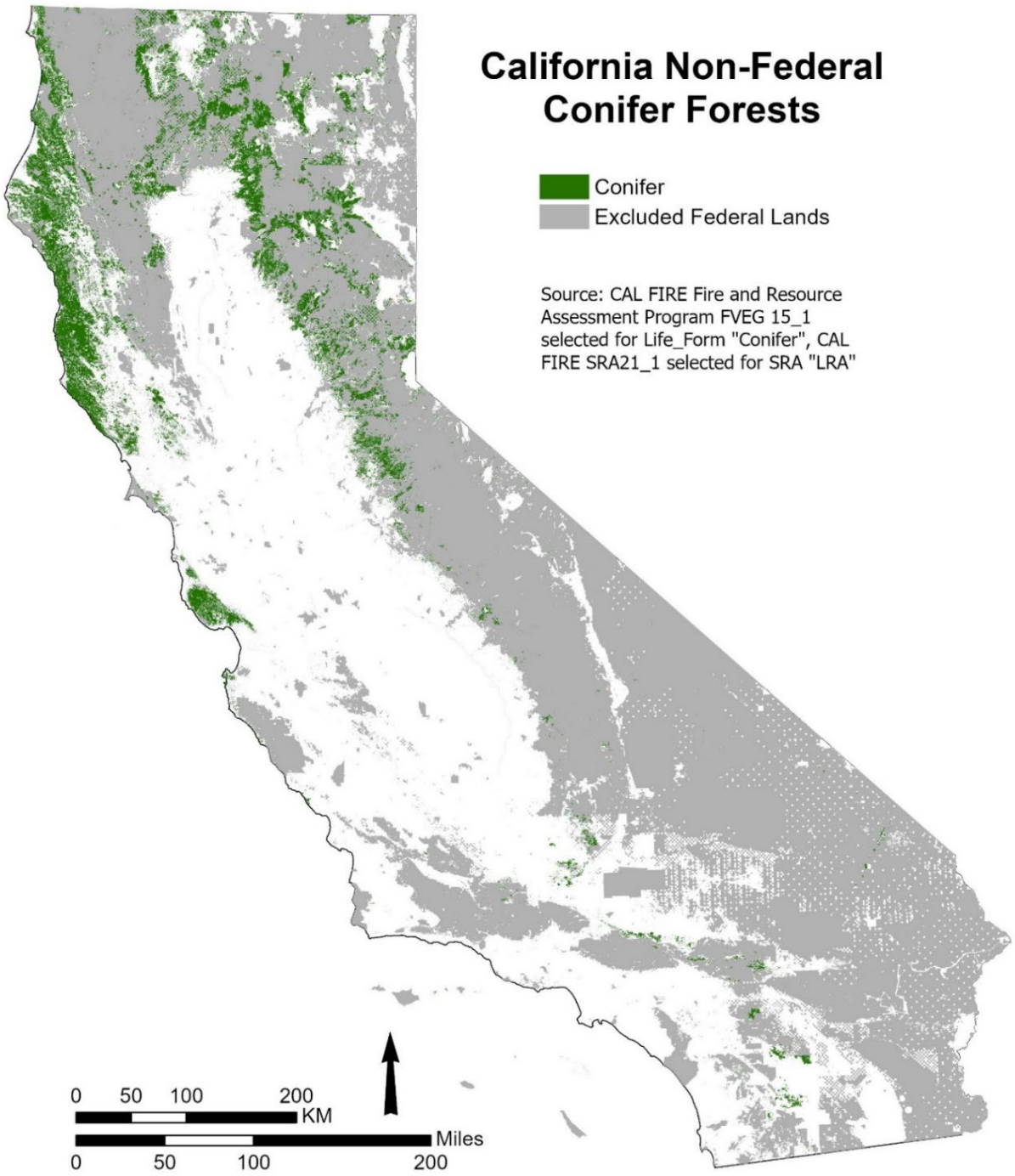


Figure 2

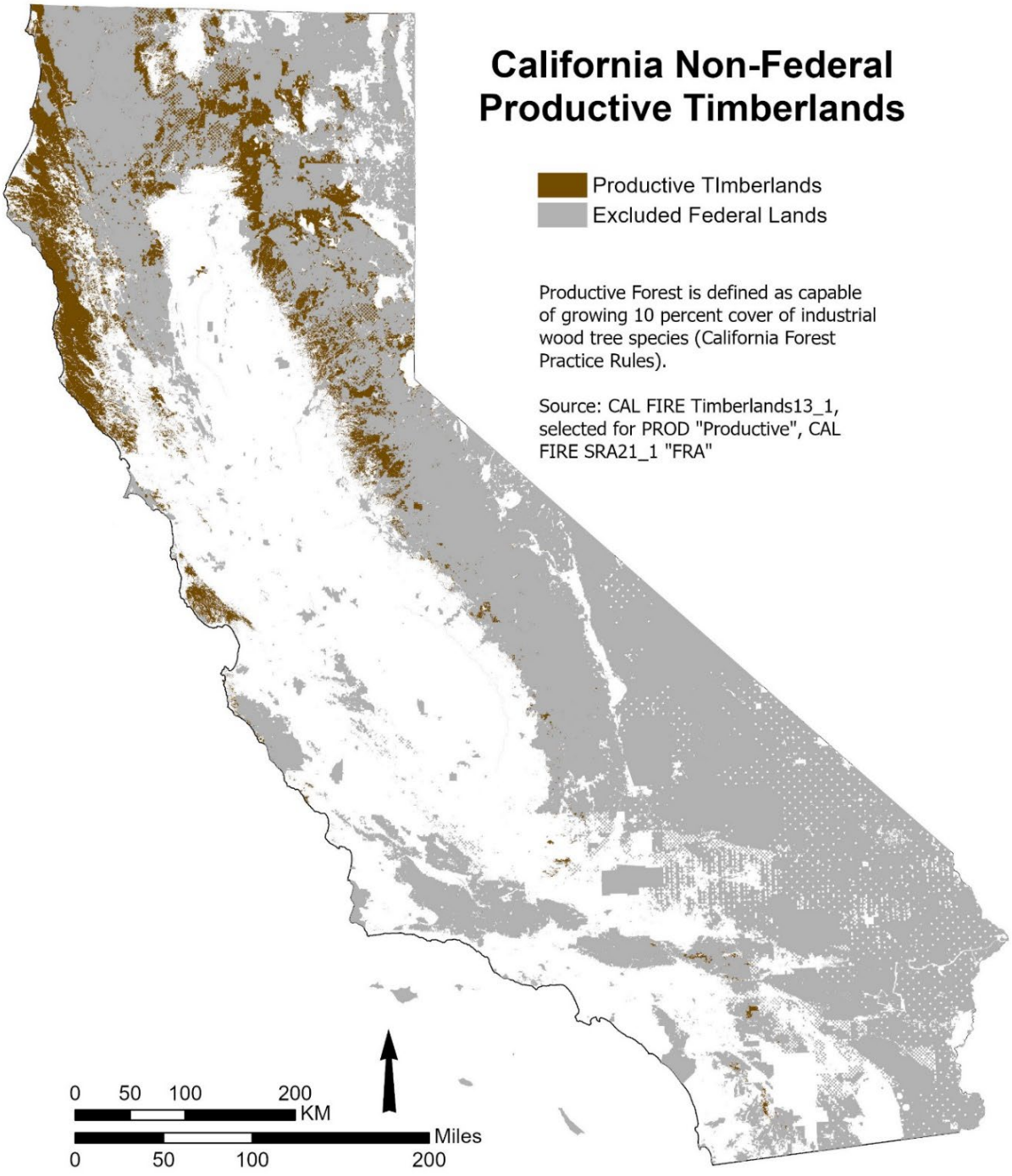

California Non-Federal
Productive Timberlands
Productive TImberlands
Excluded Federal Lands
Productive Forest is defined as capable of growing 10 percent cover of industrial wood tree species (California Forest Practice Rules).
Source: CAL FIRE Timberlands13_1, selected for PROD "Productive", CAL FIRE SRA21_1 "FRA"
0 50 100 200
KM
Miles
0 50 100 200

Figure 3

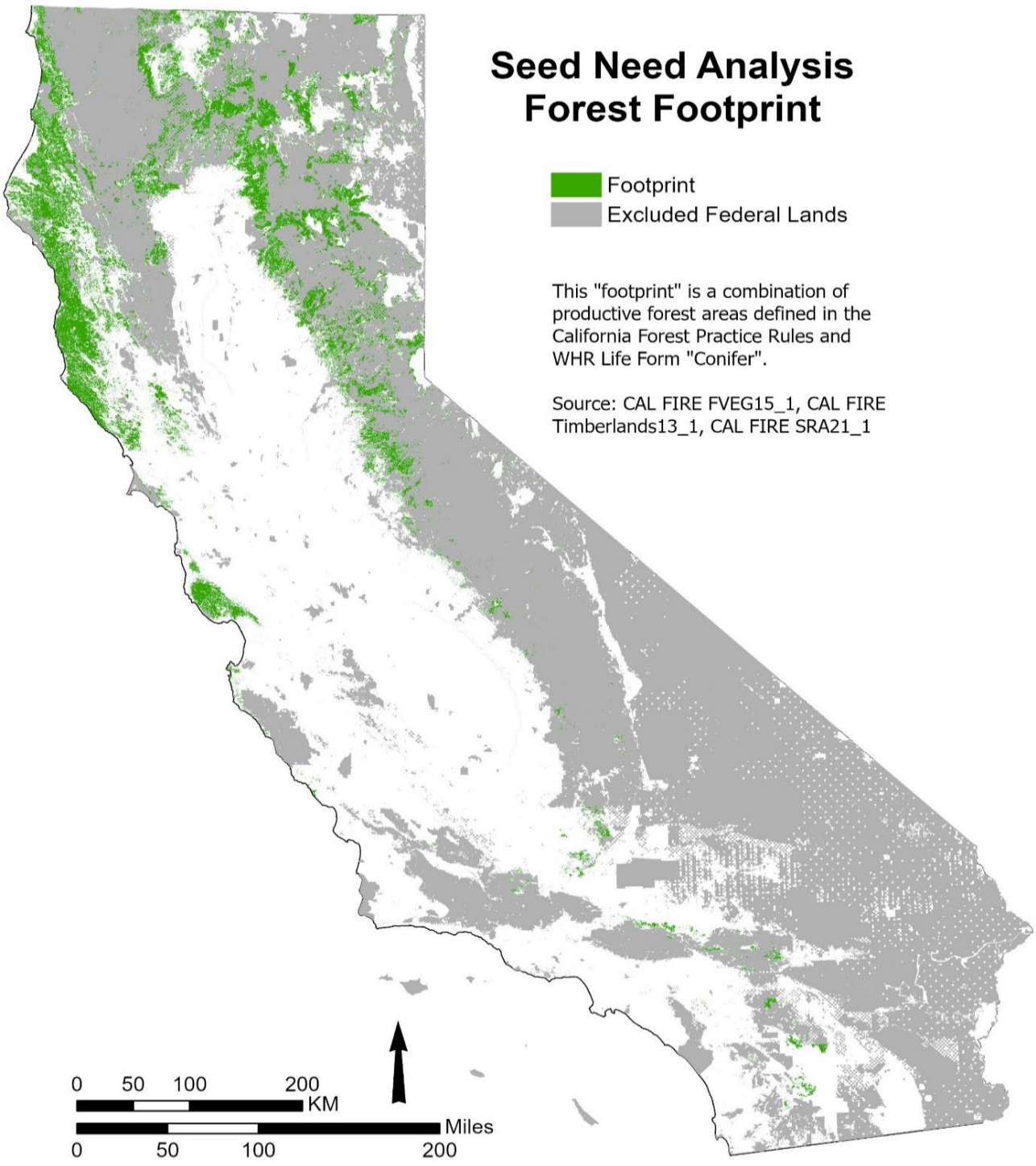

Seed Need Analysis
Forest Footprint
Footprint
Excluded Federal Lands
This "footprint" is a combination of productive forest areas defined in the California Forest Practice Rules and WHR Life Form "Conifer".
Source: CAL FIRE FVEG15_1, CAL FIRE Timberlands13_1, CAL FIRE SRA21_1
0 50 100 200
KM
Miles
0 50 100 200

Figure 4


California Seed Zones
Seed Zones
Seed zones are a three-digit numeric designation used to identify each seed collection zone. They are based on areas in California having similar climatic, topographic, and edaphic conditions.
Source: CAL FIRE seedzone02_1
Sacramento
Vacaville
Antioch
Stockton
Fremont
San Jose
Salinas
Fresno
Visalia
Santa Maria
Lancaster
Palmdale
Victorville
Santa Barbara
Santa Clarita
Oxnard
Los Angeles
Riverside
Long Beach
Murrieta
Oceanside
San Diego
Tijuana
Indio
Redding
Chico
Modoc National Forest
Lassen National Forest
Mendocino National Forest
Klamath National Forest
Trinity National Forest
Eureka
Sierra Nevada Mountains
San Joaquin Valley
Coastal Range
Sequoia National Forest
Death Valley National Park
Mojave Desert
Mojave National Preserve
0 50 100 200
KM
Miles
0 50 100 200

Figure 5

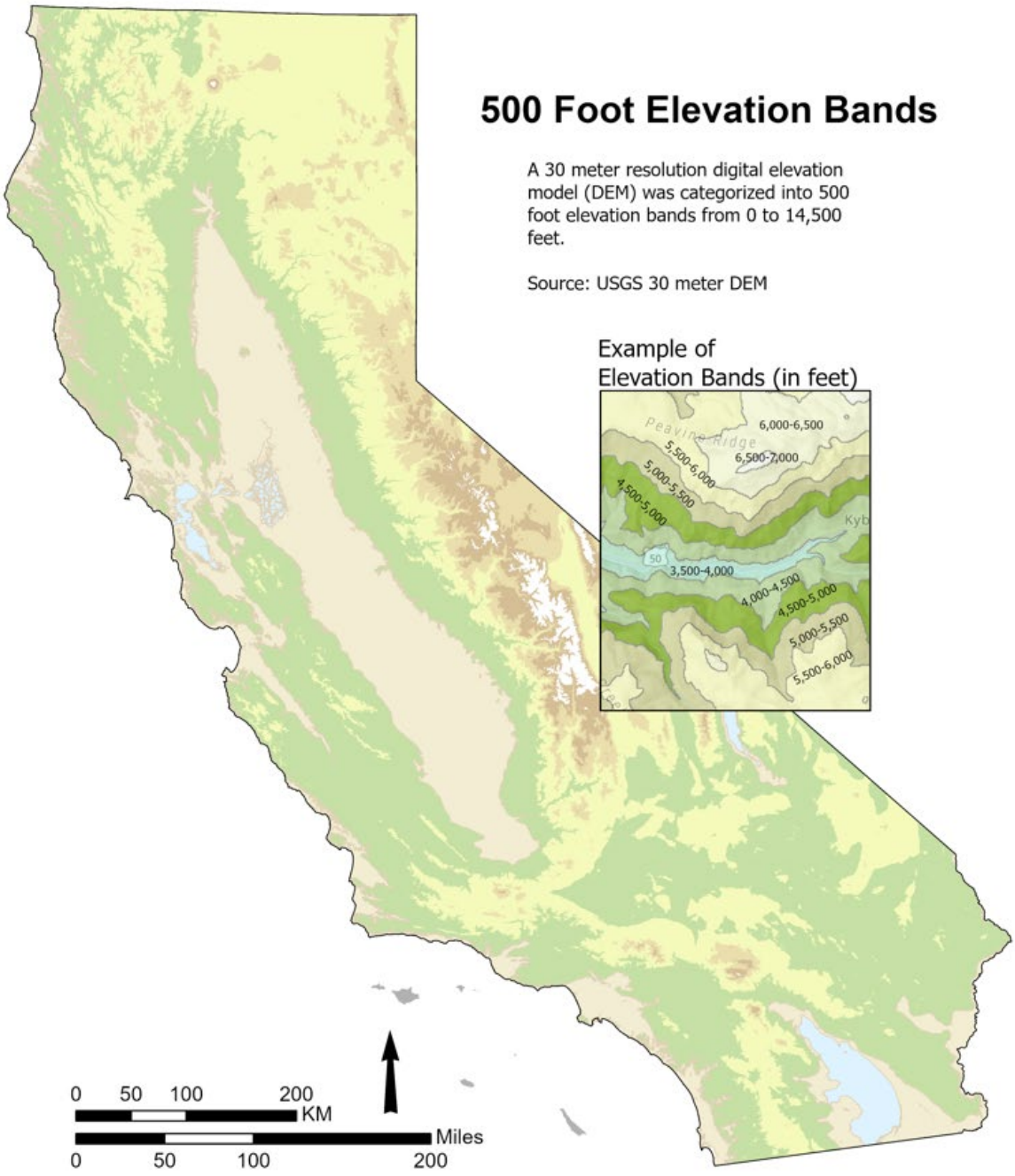

500 Foot Elevation Bands
A 30 meter resolution digital elevation model (DEM) was categorized into 500 foot elevation bands from 0 to 14,500 feet.
Source: USGS 30 meter DEM
Example of Elevation Bands (in feet)
6,000-6,500
6,500-7,000
5,500-6,000
5,000-5,500
4,500-5,000
3,500-4,000
4,000-4,500
4,500-5,000
5,000-5,500
5,500-6,000
0 50 100 200
KM
0 50 100 200
Miles

Figure 6

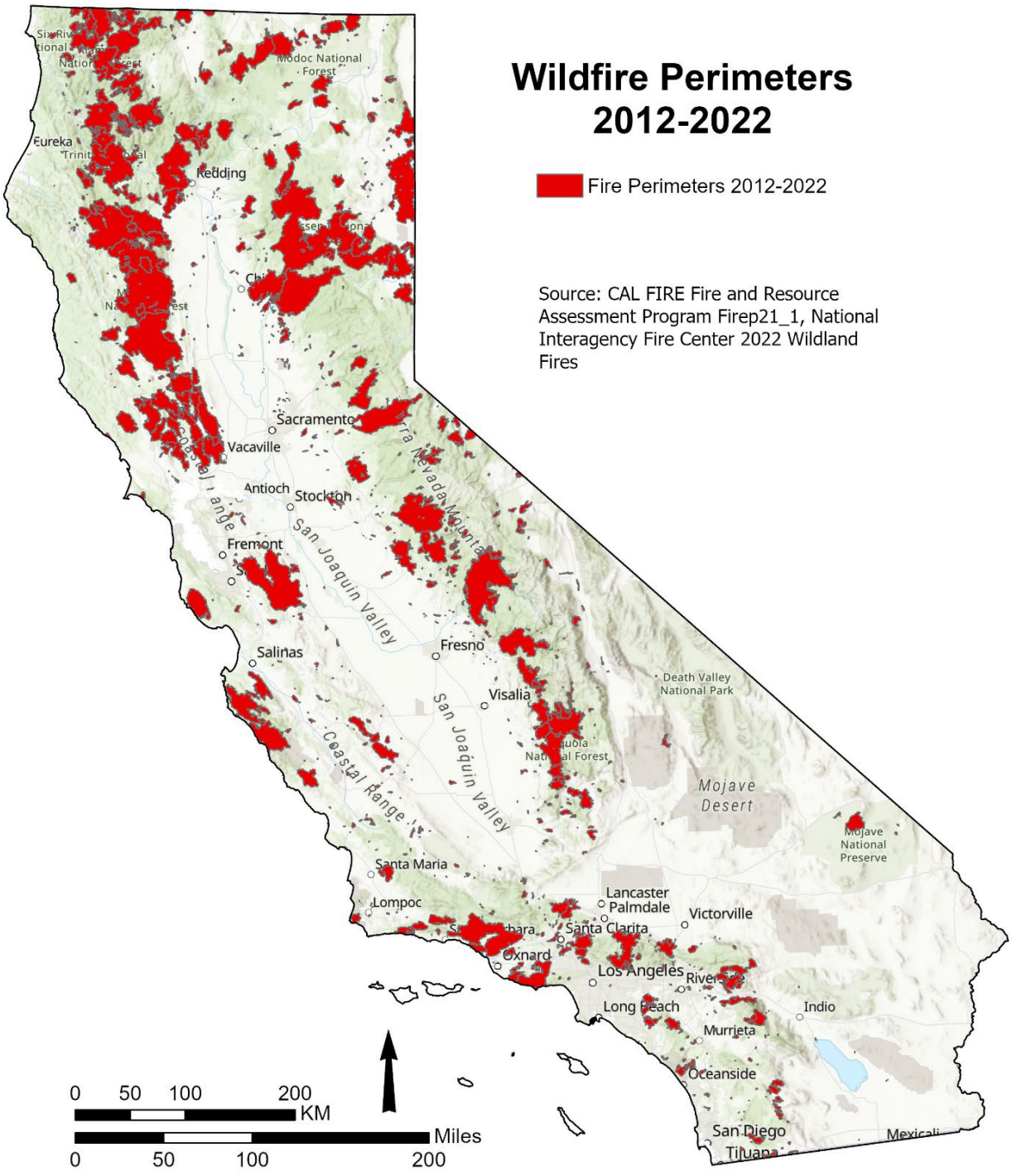
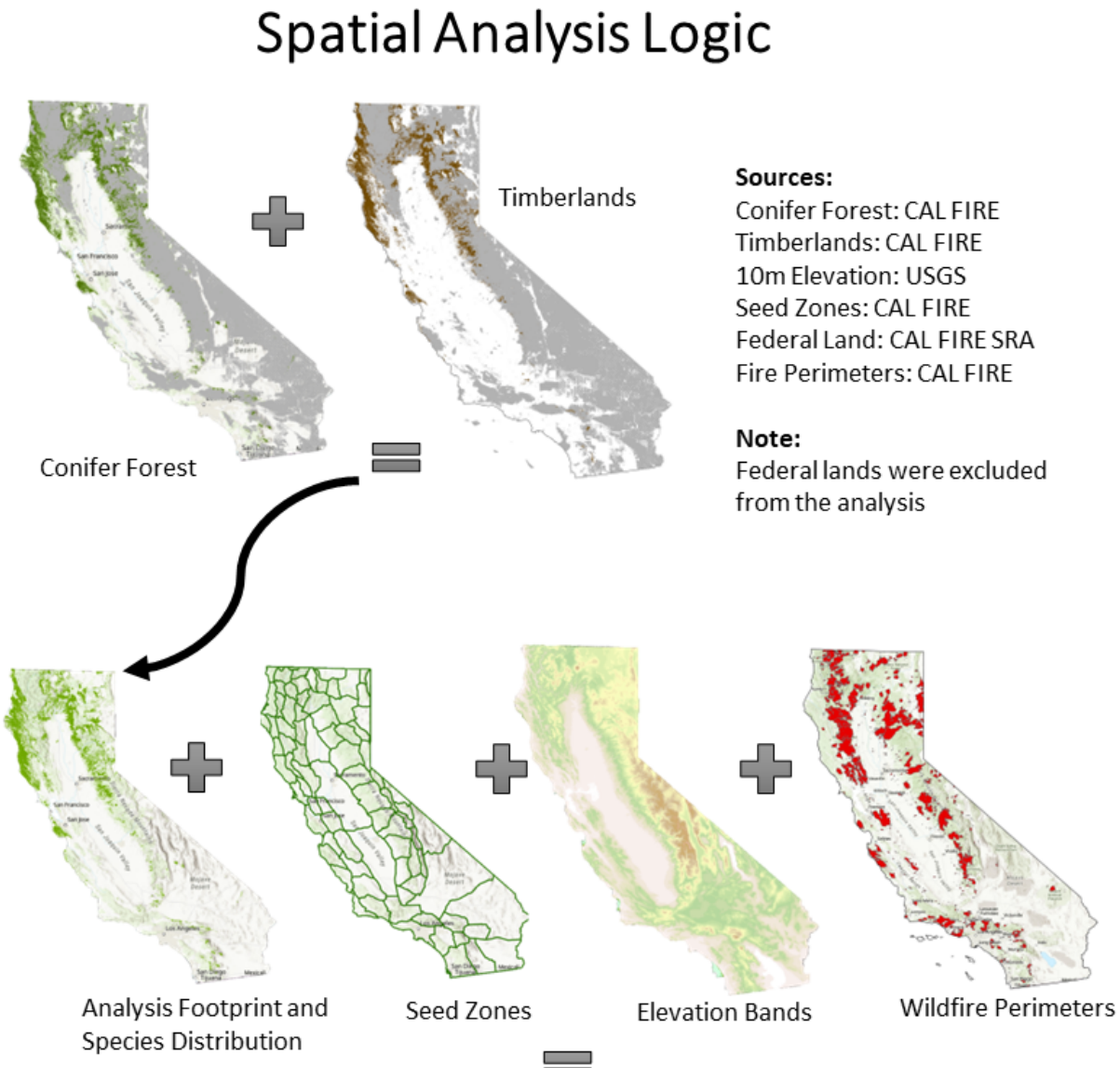

Wildfire Perimeters
2012-2022
Fire Perimeters 2012-2022
Source: CAL FIRE Fire and Resource Assessment Program Firep21_1, National Interagency Fire Center 2022 Wildland Fires
Modoc National Forest
Eureka
Redding
Sacramento
Vacaville
Antioch
Stockton
Fremont
San Joaquin Valley
Salinas
Fresno
Visalia
Death Valley National Park
Mojave Desert
Mojave National Preserve
Coastal Range
Santa Maria
Lompoc
Lancaster
Palmdale
Victorville
Santa Clarita
Oxnard
Los Angeles
Long Beach
Indio
Murrieta
Oceanside
San Diego
Tijuana
0 50 100 200 KM
0 50 100 200 Miles

Figure 7



Elevation Band	Acres of Douglas Fir	Target Acres	Seeds Needed	Pounds of Seed Needed
100-500				
1100-1500	332			
1600-2000	3,058			
2100-2500	13,395			
2600-3000	25,531	6383	1,276,569	43
3100-3500	21,830			
3600-4000	6,263			
4100-4500	2,186			
4600-5000	304			
5100-5500	2			
5500-6000				
600-1000	17			
6100-6500				
6600-7000				
7100-7500				
7600-8000				
8100-8500				
Total Needed			1,276,569	

User can filter by seed zone, elevation band, or species.

This example filters for Douglas Fir.

Appendix A – an example of filtering by seed zone. The complete dataset is extensive.

Appendix A: Tabular data obtained directly from the final spatial layer.											
Seed Zone	Elevation band adjusted	WHRNAME	WHRNAME_breakdown	adjusted acres based on WHR_Breakdown	RForest_Acres (25%)	# of trees in RF_Acres	Average seed per pound	Average seed per pot	Survival rate in nursery %	Avg_seedlings per LB	# of bushels
720	5000-5500	Eastside Pine	White Fir	194	49	9716	10596	3	1	2792	3
720	5500-6000	Eastside Pine	Douglas Fir	31	8	1565	28949	2	1	11688	1
720	5500-6000	Eastside Pine	Incense Cedar	31	8	1565	15137	3	1	3794	1
720	5500-6000	Eastside Pine	Jeffrey Pine	31	8	1565	3585	2	1	1532	1
720	5500-6000	Eastside Pine	Lodgepole Pine	31	8	1565	69195	4	1	13147	1
720	5500-6000	Eastside Pine	Ponderosa Pine	31	8	1565	9281	2	1	3968	1
720	5500-6000	Eastside Pine	White Fir	31	8	1565	10596	3	1	2792	1
720	6000-6500	Eastside Pine	Douglas Fir	16	4	799	28949	2	1	11688	1
720	6000-6500	Eastside Pine	Incense Cedar	16	4	799	15137	3	1	3794	1
720	6000-6500	Eastside Pine	Jeffrey Pine	16	4	799	3585	2	1	1532	1
720	6000-6500	Eastside Pine	Lodgepole Pine	16	4	799	69195	4	1	13147	1
720	6000-6500	Eastside Pine	Ponderosa Pine	16	4	799	9281	2	1	3968	1
720	6000-6500	Eastside Pine	White Fir	16	4	799	10596	3	1	2792	1
720	6500-7000	Eastside Pine	Douglas Fir	0	0	2	28949	2	1	11688	1
720	6500-7000	Eastside Pine	Incense Cedar	0	0	2	15137	3	1	3794	1
720	6500-7000	Eastside Pine	Jeffrey Pine	0	0	2	3585	2	1	1532	1
720	6500-7000	Eastside Pine	Lodgepole Pine	0	0	2	69195	4	1	13147	1
720	6500-7000	Eastside Pine	Ponderosa Pine	0	0	2	9281	2	1	3968	1

Appendix B- An example of filtering by species. The complete dataset is extensive.

Appendix B: LAMRC inventories matched to Appendix A to obtain actual bushels need**.**			
Species	Seed Zone	Elevation	actual bushels needed
Big-Cone Douglas Fir	991	5000-5500	115
Big-Cone Douglas Fir	992	5000-5500	163
Big-Cone Douglas Fir	993	5000-5500	26
Big-Cone Douglas Fir	994	4000-4500	1
Big-Cone Douglas Fir	994	6000-6500	23
Big-Cone Douglas Fir	996	4000-4500	2
Big-Cone Douglas Fir	998	5000-5500	11
Bishop Pine	140	0500-1000	16
Bishop Pine	91	0500-1000	1
Bishop Pine	92	1000-1500	16
Bishop Pine	94	0500-1000	13
Bishop Pine	95	0500-1000	2
Coast Redwood	100	0500-1000	1
Coast Redwood	100	1000-1500	2
Coast Redwood	100	1500-2000	2
Coast Redwood	100	2000-2500	1
Coast Redwood	110	0500-1000	1
Coast Redwood	110	1000-1500	6
Coast Redwood	110	1500-2000	10
Coast Redwood	110	2000-2500	3
Coast Redwood	120	0500-1000	4
Coast Redwood	120	1000-1500	13
Coast Redwood	120	1500-2000	12

Appendix C. An example of filtering by wildfire name. The complete dataset is extensive.

Appedix C: Fire data						
SEED_ZONE	Unit	YEAR_	FIRE_NAME	Perimeter Acres	total acres	1,336,136
524	Butte Unit	2020	1-12 / BUTTE LIGHTNING COMPLEX	891		
524	Butte Unit	2020	1-7 / BUTTE LIGHTNING COMPLEX	174		
321	Siskiyou Unit	2017	ABNEY	603		
511	Siskiyou Unit	2017	ABNEY	457		
771	Lassen-Modoc Unit	2020	ADAMS	1		
531	Tuolumne-Calaveras Unit	2021	AIROLA	3		
534	Tulare Unit	2018	ALDER	582		
731	Lassen-Modoc Unit	2021	ALLEN	133		
731	Lassen-Modoc Unit	2020	ALLEN	133		
525	Nevada-Yuba-Placer Unit	2013	AMERICAN	4,353		
720	Siskiyou Unit	2021	Antelope	542		
741	Siskiyou Unit	2021	Antelope	15,086		
742	Siskiyou Unit	2021	Antelope	333		
772	Nevada-Yuba-Placer Unit	2021	ANTELOPE	12		
772	Nevada-Yuba-Placer Unit	2020	ANTELOPE	5		
731	Lassen-Modoc Unit	2012	ANTELOPE	8		
994	Riverside Unit	2020	APPLE	27		
994	San Bernardino Unit	2020	APPLE	1,584		
525	Nevada-Yuba-Placer Unit	2014	APPLEGATE	201		
532	Fresno-Kings Unit	2013	ASPEN	27		
532	Madera-Mariposa-Merced Unit	2013	ASPEN	0		
380	Sonoma-Lake Napa Unit	2017	ATLAS	127		
303	Humboldt-Del Norte Unit	2020	AUGUST COMPLEX FIRES	0		
303	Shasta-Trinity Unit	2020	AUGUST COMPLEX FIRES	179		

Appendix D. Seed Bank AON tool.

Species	Seed Zone	Elevation	Number of bushels needed	Unit	Fire Name in seed zones	Grand total of bushels needed
Douglas Fir	525	2500-3000	163	AEU,BTU,LMU,NEU	AMERICAN/APPLEGATE/Bear/CASSCADE CREEK/DOGBAR/JONES/KING/LOBO/LOWELL/LUMPKIN/NORTH/NORTH COMPLEX/PLEASANT/PONDEROSA/River/ROBBERS/TRAILHEAD	76,304
Incense Cedar	525	3500-4000	146	AEU,BTU,LMU,NEU	AMERICAN/APPLEGATE/Bear/CASSCADE CREEK/DOGBAR/JONES/KING/LOBO/LOWELL/LUMPKIN/NORTH/NORTH COMPLEX/PLEASANT/PONDEROSA/River/ROBBERS/TRAILHEAD	
Incense Cedar	525	4000-4500	255	AEU,BTU,LMU,NEU	AMERICAN/APPLEGATE/Bear/CASSCADE CREEK/DOGBAR/JONES/KING/LOBO/LOWELL/LUMPKIN/NORTH/NORTH COMPLEX/PLEASANT/PONDEROSA/River/ROBBERS/TRAILHEAD	
Incense Cedar	525	5000-5500	172	AEU,BTU,LMU,NEU	AMERICAN/APPLEGATE/Bear/CASSCADE CREEK/DOGBAR/JONES/KING/LOBO/LOWELL/LUMPKIN/NORTH/NORTH COMPLEX/PLEASANT/PONDEROSA/River/ROBBERS/TRAILHEAD	
Ponderosa Pine	525	2000-2500	103	AEU,BTU,LMU,NEU	AMERICAN/APPLEGATE/Bear/CASSCADE CREEK/DOGBAR/JONES/KING/LOBO/LOWELL/LUMPKIN/NORTH/NORTH COMPLEX/PLEASANT/PONDEROSA/River/ROBBERS/TRAILHEAD	
Ponderosa Pine	525	3500-4000	117	AEU,BTU,LMU,NEU	AMERICAN/APPLEGATE/Bear/CASSCADE CREEK/DOGBAR/JONES/KING/LOBO/LOWELL/LUMPKIN/NORTH/NORTH COMPLEX/PLEASANT/PONDEROSA/River/ROBBERS/TRAILHEAD	
Ponderosa Pine	525	4000-4500	150	AEU,BTU,LMU,NEU	AMERICAN/APPLEGATE/Bear/CASSCADE CREEK/DOGBAR/JONES/KING/LOBO/LOWELL/LUMPKIN/NORTH/NORTH COMPLEX/PLEASANT/PONDEROSA/River/ROBBERS/TRAILHEAD	
Red Fir	525	7000-7500	216	AEU,BTU,LMU,NEU	AMERICAN/APPLEGATE/Bear/CASSCADE CREEK/DOGBAR/JONES/KING/LOBO/LOWELL/LUMPKIN/NORTH/NORTH COMPLEX/PLEASANT/PONDEROSA/River/ROBBERS/TRAILHEAD	
Red Fir	525	8000-8500	128	AEU,BTU,LMU,NEU	AMERICAN/APPLEGATE/Bear/CASSCADE CREEK/DOGBAR/JONES/KING/LOBO/LOWELL/LUMPKIN/NORTH/NORTH COMPLEX/PLEASANT/PONDEROSA/River/ROBBERS/TRAILHEAD	
Sugar Pine	525	4000-4500	243	AEU,BTU,LMU,NEU	AMERICAN/APPLEGATE/Bear/CASSCADE CREEK/DOGBAR/JONES/KING/LOBO/LOWELL/LUMPKIN/NORTH/NORTH COMPLEX/PLEASANT/PONDEROSA/River/ROBBERS/TRAILHEAD	
Sugar Pine	525	5000-5500	143	AEU,BTU,LMU,NEU	AMERICAN/APPLEGATE/Bear/CASSCADE CREEK/DOGBAR/JONES/KING/LOBO/LOWELL/LUMPKIN/NORTH/NORTH COMPLEX/PLEASANT/PONDEROSA/River/ROBBERS/TRAILHEAD	
Sugar Pine	525	5500-6000	137	AEU,BTU,LMU,NEU	AMERICAN/APPLEGATE/Bear/CASSCADE CREEK/DOGBAR/JONES/KING/LOBO/LOWELL/LUMPKIN/NORTH/NORTH COMPLEX/PLEASANT/PONDEROSA/River/ROBBERS/TRAILHEAD	
Sugar Pine	525	6500-7000	107	AEU,BTU,LMU,NEU	AMERICAN/APPLEGATE/Bear/CASSCADE CREEK/DOGBAR/JONES/KING/LOBO/LOWELL/LUMPKIN/NORTH/NORTH COMPLEX/PLEASANT/PONDEROSA/River/ROBBERS/TRAILHEAD	
White Fir	525	5500-6000	134	AEU,BTU,LMU,NEU	AMERICAN/APPLEGATE/Bear/CASSCADE CREEK/DOGBAR/JONES/KING/LOBO/LOWELL/LUMPKIN/NORTH/NORTH COMPLEX/PLEASANT/PONDEROSA/River/ROBBERS/TRAILHEAD	
White Fir	525	6000-6500	124	AEU,BTU,LMU,NEU	AMERICAN/APPLEGATE/Bear/CASSCADE CREEK/DOGBAR/JONES/KING/LOBO/LOWELL/LUMPKIN/NORTH/NORTH COMPLEX/PLEASANT/PONDEROSA/River/ROBBERS/TRAILHEAD	
Douglas Fir	525	2000-2500	44	AEU,BTU,LMU,NEU	AMERICAN/APPLEGATE/Bear/CASSCADE CREEK/DOGBAR/JONES/KING/LOBO/LOWELL/LUMPKIN/NORTH/NORTH COMPLEX/PLEASANT/PONDEROSA/River/ROBBERS/TRAILHEAD	
Douglas Fir	525	4000-4500	17	AEU,BTU,LMU,NEU	AMERICAN/APPLEGATE/Bear/CASSCADE CREEK/DOGBAR/JONES/KING/LOBO/LOWELL/LUMPKIN/NORTH/NORTH COMPLEX/PLEASANT/PONDEROSA/River/ROBBERS/TRAILHEAD	
Douglas Fir	525	4500-5000	63	AEU,BTU,LMU,NEU	AMERICAN/APPLEGATE/Bear/CASSCADE CREEK/DOGBAR/JONES/KING/LOBO/LOWELL/LUMPKIN/NORTH/NORTH COMPLEX/PLEASANT/PONDEROSA/River/ROBBERS/TRAILHEAD	
					AMERICAN/APPLEGATE/Bear/CASSCADE	